CAAM 382 Stochastic Models
Spring 2020

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Course Description: The aim of the course is to enable the students to build and analyze mathematical models of real-life situations where uncertainty is present. The applications are drawn from a wide variety of areas: manufacturing, inventory, reliability, biology, computer science, telecommunications, health-care systems, etc. Some knowledge of basic probability (familiarity with random variables, probability distribution functions, moments of random variables, expectations, conditional probability and expectations) will be assumed. The following topics will be covered: Discrete & continuous time Markov models, Poisson processes, queueing systems, Markov decision processes, optimal design and control. We will use MATLAB to solve numerical problems.

Prerequisites:

- MATH 102;
- Familiarity with basic probability e.g., random variables, probability distribution functions, moments of random variables;
- Familiarity with a scientific programming language, e.g., Matlab, Python, R, Java;
- Familiarity with multivariable calculus and elementary matrix manipulations (matrix addition and multiplication, Gaussian elimination).

Recommended Prerequisites:
STAT 280, 305, 310 or 315;
MATH 212;
CAAM 210 or COMP 140;
CAAM 335 or MATH 355.

Text Book: F. Hillier and G. Lieberman, Introduction to Operations Research, McGraw Hill, 10th Edition, 2014.

Reference Textbooks:

- S.M. Ross, Introduction to Probability Models, Academic Press, 12th Edition, 2019.
- V.G. Kulkarni, *Modeling, Analysis, Design, and Control of Stochastic Systems*, Springer -Verlag, New York, 1999.
- E. Cinlar, Introduction to Stochastic Processes, Dover Books on Mathematics, 2013.

Grading:

1. Homework 30%
2. Midterm exam 25%
3. Final exam 35%
4. Project 10%

Learning Outcomes:

By the end of this course, students will be able to

- describe fundamental modeling tools for situations where uncertainty exists;
- develop discrete- and continuous-time Markov models of systems;
- understand basic principles of renewal theory and use them for performance calculations;
- model production and service systems using queueing models, and calculate long-run average performance measures;
- construct models for sequential decision making under uncertainty, and determine optimal decisions for design and operations of various systems.

Couse Guidelines:

Class Attendance: It is strongly recommended that you attend all classes and arrive on time for each class. Active participation in class is also expected. Students who must miss a class or assignment because of unavoidable circumstances should consult with the instructor well in advance so that alternative arrangements may be made. Students are responsible for all material presented, assigned, or collected during class, regardless of whether absent or present.

Canvas: Course materials, announcements, grades or changes to the course outline will be posted on Canvas. It is the student's responsibility to check Canvas before every class period for important announcements, class notes, emails, grades and changes to the course schedule. If you have a question about the course and/or assignments, please feel free to post it on the Canvas website under the "Discussions" tab. If you see a question there and you know the answer, you are welcome to answer. Discussions on Canvas and in person are highly encouraged.

Technology in class: Please turn off all electronics before entering class. During class time, students are allowed to use their laptop computers only for computational exercises (not for email, web surfing, etc.) under the instructor's supervision.

Homework assignments: There will be approximately one assignment per week, posted on Canvas. You can discuss homework problems with your classmates, but you are expected to complete each assignment on your own. Homework assignments are due in the beginning of the class. Each of you receive two free late assignments. The late assignments must be used on different assignments. When you turn in a late assignment, please include a pledged statement saying that this is your first or second free late assignment. The late homework extends a deadline one class meeting.

Rice Honor Code:
In this course, all students will be held to the standards of the Rice Honor Code, a code that you pledged to honor when you matriculated at this institution. If you are unfamiliar with the details of this code and how it is administered, you should consult the Honor System Handbook at http://honor.rice.edu/honor-system-handbook/. This handbook outlines the University's expectations for the integrity of your academic work, the procedures for resolving alleged violations of those expectations, and the rights and responsibilities of students and faculty members throughout the process. Honor code violations are very serious, and can lead to dismissal from the university.

Disability Resource Center:
If you have a documented disability or other condition that may affect academic performance you should: 1) make sure this documentation is on file with the Disability Resource Center (Allen Center, Room 111 / adarice@rice.edu / x5841) to determine the accommodations you need; and 2) talk with me to discuss your accommodation needs.

Tentative Course Outline:
Week 1: Review of conditional probability and expectations,
Introduction to discrete-time Markov chains (DTMCs)
Week 2: Examples of modeling with DTMCs
Week 3: Chapman-Kolmogorov equations; classification of states
Week 4: Limiting behavior, cost models & first passage times in DTMCs
Week 5: Examples of modeling with continuous-time Markov chains (CTMCs)
Week 6: Poisson processes; Transient analysis of CTMCs
Week 7: Limiting behavior & cost models of CTMCs
Week 8: Renewal theory & its applications
Week 9: Introduction to queuing models
Week 10: Birth & death queues with finite & infinite capacities
Week 11: General queueing approximations; networks of queues
Week 12: Reliability
Week 13: Markov Decision Processes
Week 14: Markov Decision Processes